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ABSTRACT

The accessibility of the World Wide Web and its flexibility for conveying digital information in various forms makes it a convenient mode of communication for education. With the help of a distance learning application called "Easy Ed," this paper demonstrates how these properties of the Web along with a data model can be used to provide a classroom environment on the Internet. Easy Ed provides a rich medium for education that is achieved by integrating information across the different media types (text, video, audio, and graphics) in hypermedia form. Metadata conforming to the data model about different media types is stored in a relational database, which not only facilitates authoring, but also makes it possible to reuse existing instructional material. Another concept of Easy Ed is the dynamic repurposing of content at the time of access. Dynamic information generation helps to customize information according to a user's level of comprehension, the information medium, and hardware compatibility. Five figures present customization and page composition, the system architecture of Easy Ed, object hierarchy in a topic, an example of tour formation, and the interface for display of course views and contents. (Author/AEF)

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Easy Ed: An Integration of Technologies for Multimedia Education

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Abstract: The accessibility of the World Wide Web and its flexibility for conveying digital information in various forms makes it a convenient mode of communication for education. In this paper with the help of a distance learning application called "Easy Ed," we demonstrate how these properties of the World Wide Web along with a *data model* can be used to provide a classroom environment on the Internet. Easy Ed provides a rich medium for education that is achieved by integrating information across the different media types (text, video, audio, and graphics) in hyper-media form. Metadata conforming to the data model about different media types is stored in a relational database, which not only facilitates authoring but also makes it possible to reuse existing instructional material. Another unique concept of Easy Ed is the *dynamic repurposing* of content at the time of access. Dynamic information generation helps to customize information according to a user's level of comprehension, the information medium, and hardware compatibility.

Introduction

Distance education involves providing a user with instructional material for self or group learning for geographically dispersed students. The basic outline for instructional material can be established by domain experts that will remotely supervise a student. Distance education is not meant to replace the instructor or other experts but to let a larger audience benefit from their expertise. From the student's perspective it is much more convenient if the user can view information at convenience both with respect to time and duration of viewing. As an outcome of a study conducted by Wetzel et al. [Wetzel et al. 1994] on the effectiveness of video as a learning medium it was noted that the medium of education should be non-linear and dynamically paced. For example, a student can follow links for additional information on a particular topic and then continue with better understanding. As the information can be accessed remotely, the World Wide Web (WWW) and the Internet make information time- and place-independent [Harasim 1990]. Access to geographically isolated communities, multiple participation, and sharing of diversity and similarity among people can also be added to the benefits of distance education via the Internet [Schrum and Lamb 1996].

A number of experiments [Hiltz 1995, Rada 1996, Schrum and Lamb 1996] have been conducted to assess the effectiveness of distance education as compared to a conventional classroom environments. The results show that the mastery of material of students using digital libraries is equal or superior to that of a traditional classroom. Students are able to better synthesize or establish relationships between diverse ideas. These results are judged successful especially with students who worked full time or those who were geographically scattered. Though such experiments are a success they do not utilize the full capabilities of the WWW and the Internet, i.e., the capability of providing true multimedia information. To further benefit from multimedia technology, we need to integrate information of diverse forms including video, audio, text, and images to provide a richer hyper-linked medium for learning. For example, in addition to textual information about how to perform a chemistry experiment, one might provide a link to a video clip of an expert demonstrating the experiment.

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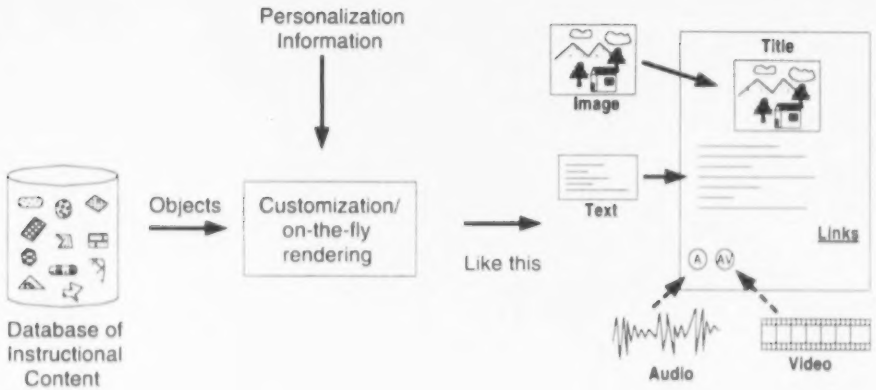

Figure 1: Customization and Page Composition

Easy Ed, a distance learning application, is a result of our investigation of technologies for integrating educational material from various media types. In addition to being a true multimedia distance learning application, Easy Ed has a number of novelties. First, it dynamically generates a course from metadata stored in a relational database on-the-fly. Various related multimedia objects are integrated at the time of rendering information, i.e., the information is not pre-composed [Fig. 1]. This not only makes it easier to reuse the objects but at the same time reduces the opportunity for material to be reproduced en masse. Second, this technique eliminates the need for data replication (e.g., if the same instance of text is to be displayed in two different topics we only require a single instance in our archive, whereas pre-composed static documents of the same text requires replication). Not replicating the data makes a considerable difference in storage savings for large instructional content (e.g., video). Third, the use of *dynamic document generation* helps in customization of information. Depending on a user's preferences the information can be easily filtered to reduce excess content (e.g., if a network capacity does not allow realtime delivery of video then this medium can be omitted). Fourth, authoring is simplified as an author can form a new course from existing information by identifying relationships between different objects. Fifth, an effective medium of learning is provided in Easy Ed by integrating concepts of different media types. Finally, we have simulated the look and feel of a conventional book but with the incorporation of content-based *tours* and searching.

In addition to providing an integrated environment for education, we are also motivated by our desire to reuse legacy video-based instructional materials existing in our own lab. Some of the specific objectives in this effort are:

- Offer dynamic or self-paced education.
- Provide non-sequential access for improved learning.
- Provide tailored material for individual needs.
- Save costs of creation and delivery.
- Allow courses not offered in a semester to be made available.
- Allow access to related courses.
- Allow remote access.

Hence, with these objectives and a desire for a true multimedia application, we set out to create the distance learning application called Easy Ed.

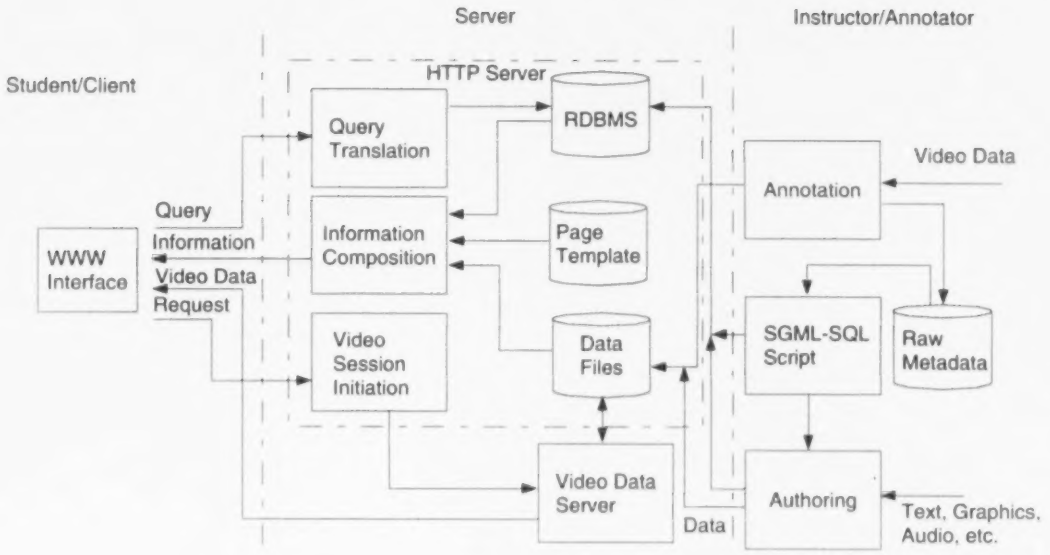

Figure 2: System Architecture of Easy Ed

Architecture and Features of Easy Ed

The architecture of Easy Ed can be divided into three parts; instructor/annotator, student/client, and server. The annotator extracts information from raw data based on an instructional data model. The extracted information is then stored in a relational database. The client component provides a student with means of access to the stored information. The server deals with processing client requests, searching, and composition of data prior to delivery to the client.

The unique features (e.g., dynamic document generation) supported by Easy Ed are a result of the data model and composition process. The instructional data model is based on *context*. A random segment of a topic is not enough to comprehend the meaning of what is being said completely, a context has to be established. Therefore, the unit of information rendered is in the form of a *topic* and a course is offered as a set of topics. Each topic can be composed of graphics, text, and hyper-links to information in the form of text, video, graphics, or audio. Providing links to related video segments achieves non-linear and self-paced viewing of video. The informational components are treated as objects, a single object can belong to multiple topics, and a topic (single or multiple instance) can belong to multiple courses. For example, consider a topic being taught in two courses or in the same course but at different times. Therefore, we achieve different instances of the same topic. We consider each instance of the topic as a separate identity but with conceptual association. Some of the important capabilities supported by the data model are as follows:

- **Customization:** The database is designed to limit access after authoring by only allowing delivery of a subset of the objects to the client on request. This is easily achieved by treating the contents of the instructional database as distinct objects and combining these objects at the time of rendering. In the instruction database the objects are "page," "graphics," "video," "transcript," "audio," and "links" [Fig. 3]. Each topic is composed of pages which can be viewed sequentially to establish context and provide controlled information. The page object is a container for objects it contains (i.e., graphics, text, references, audio, and video).

- **Tours:** The ordering of the presentation of the topics in a course can be changed by changing the order in the relational database, thereby generating different "tours" for the same course. [Fig. 4]

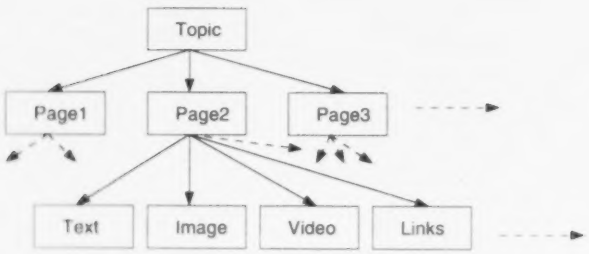

Figure 3: Object Hierarchy in a Topic

depicts a scenario of tour formulation for a particular topic. Tours are useful if a course can be offered at varying levels of difficulty (e.g., beginner, intermediate, and advanced).

- **Fast Access:** Components such as abstract, transcript, related text, audio, or video systems streams are used to provide information at different granularities. A user can browse through the database using the concepts provided or using a complete keyword search, accessing at any of these granularities.
- **Authoring & Repurposing:** The authoring of existing courses or any new course is simplified by the data model. An instructor can identify new relationships between objects to create a news topic or a course. An instructor does not have to manually assemble information. Not only existing informational material (e.g., images, text, video clips) can be used for composing new courses but any new material can be easily added as objects to the database for integration into a course.

Operation

On initial access, a student can browse the database by "Course," "Topic," "Instructor," and "Year." If the search is made by course name/number then the system lists titles and creation dates of all courses in the database satisfying the query. When a student chooses a course then the system generates a *view* of that course and displays it to a student as shown in [Fig. 5]. A view displays the course and various available tours (e.g., beginner, intermediate, and advanced) associated with it. Once a student selects a view, all the topics offered in the view are displayed and by clicking on a particular topic the contents are displayed. The browse mechanisms for "Topic," "Year" and "Instructor" operate in a similar manner.

In addition to browsing the database, a student can search for particular content in the database. The student can search using a form-based interface with details about the "Course ID," "Course Title," "Year," "Topic," "Instructor," and "Session." The student can fill in any one of the fields or any combination of these fields. To provide a more detailed search, a search based on "keywords" can also be executed.

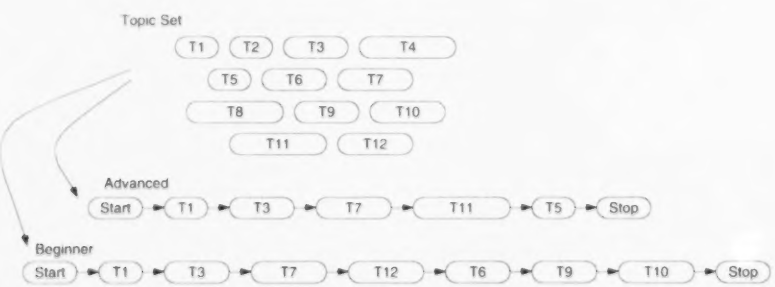

Figure 4: An Example of Tour Formation

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Query Processing

Once a student issues a query (e.g., clicks on a certain topic in the Course View Interface), a Common Gateway Interface (CGI) script of the WWW server is executed translating the query into the Structured Query Language (SQL) format and sends the query to a relational database as shown in [Fig. 2]. The system finds all page objects contained in the selected topic and then finds the objects contained within each page. The retrieved information is sent through an information composition module which composes the information according to the template provided. If a topic has more than one page then a series of pages are composed and are dynamically linked together and delivered to the student. Graphics and text are rendered in a WWW interface and links are provided to any relevant video or audio clips.

Implementation

We use a relational database called Mini SQL (mSQL) [Hughes 1995] as a database interface from a RDBMS to HTTP server. The database interfaces with the WWW by the C language API of mSQL. Video indexing is performed using a graphical annotation tool called Vane [Carrer et al. 1997]. The metadata are stored in conformance with the SGML format tailored to video data as specified for Vane. The database is automatically populated with metadata from the SGML files with the help of scripts written in Perl 5.

The client is written using HTML and JavaScript. Because the URL addresses are resolved on-the-fly, utilizing JavaScript is very convenient. A WWW browser is used to display the images, text, and audio. To play video, a student initiates a streaming session by a click on a video icon. Streaming is implemented using our own protocol which achieves a small start up latency and lossless delivery. The video is displayed in a separate window.

Summary

This research is based on our investigation of technologies for digital video archival and distribution. We have created a hyper-media environment for distance learning by linking small, cohesive units of video data with text. This not only provides important visual information but at the same time allows self-paced education.

The data model is simple and flexible because coherent information units are treated as objects. Dynamic assembly of information at the time of rendering makes the process of customization straightforward. Objects are incorporated or deleted depending on a student's preferences or the network's and client's capabilities, thereby providing fast access to information at various granularities. Dynamic repurposing not only allows an object to be part of different courses simultaneously but achieves storage savings; objects are replicated only at the time of rendering. Students with various levels of expertise can be serviced by different tours of a course by storing different sequences of topics in the relational database.

Thus, Easy Ed in addition to having a look and feel of a conventional book, efficiently integrates information in multiple media. It provides a flexible access to information while accommodating student preferences in a platform-independent manner.

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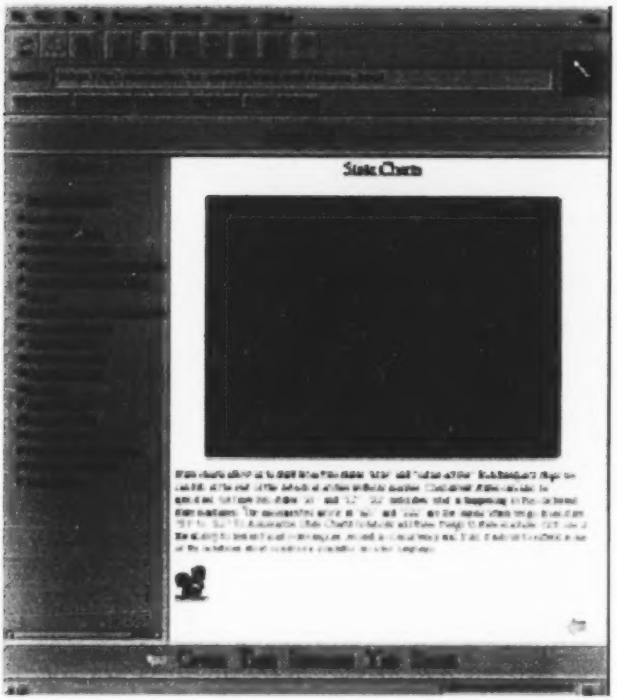

Figure 5: Interface for Display of Course Views and Contents

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